

Claims

1. Method for designing a technical system which is characterized by parameters, including state variables and
5 diagnostic variables which depend on the state variables:
- in which the technical system is specified by a system of equations, with the state variables being the solutions of the system of equations;
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 - in which a measurement park, incorporating first measured variables, is analyzed, whereby the first measured variables are measured in the technical system with a prescribed accuracy, and depend on the state variables;
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 - in which second measured variables, which depend on the state variables, can be measured in the technical system with a predetermined accuracy;
 - 20 - in which first sensitivity variables are determined for the first measured variables and/or second sensitivity variables for the second measured variables;
 - in which, to determine the first sensitivity variables, a
25 determination is made of the magnitude of the influence which a change in the accuracy of measurement of the first measured variables has on at least one selected parameter, and to determine the second sensitivity variables, a
30 determination is made of the magnitude of the influence which the measurement of the second measured variables has on at least one selected parameter;
 - in which the measurement park is changed, depending on the

first and/or second sensitivity variables, in such a way that the accuracy of one or more of the first measured variables is changed and/or one or more of the first measured variables is taken out of the measurement park and/or one or more of the second measured variables is added into the measurement park;

- in which the amended measurement park is used in designing the technical system.

2. Method in accordance with claim 1, whereby the accuracy of a first measured variable is increased if the first sensitivity variable for this measured variable lies within a predefined value range and/or a first measured variable is taken out of the measurement park if the first sensitivity variable for this measured variable lies within a predefined value range and/or a second measured variable is added into the measurement park if the second sensitivity variable for this measured variable lies within a predefined value range.

3. Method in accordance with claim 1 or 2, whereby the technical system is described by a system of equations $H(x) = (H_1(x), \dots, H_m(x)) = 0$, where $x = (x_1, \dots, x_n)$ is a vector in which the components are the state variables x_i .

4. Method in accordance with claim 3, in which the following matrices are calculated:

- a matrix N , which spans the null space of the Jacobian matrix of H ,
- a matrix W , such that $W^T \cdot W$ is the inverse of the covariance matrix of the first measured variables $y_i = b_i(x)$, where the entries in the covariance matrix are the covariances $\sigma_{ij}^2 = E((y_i - E(y_i))(y_j - E(y_j)))$, where

$E(y)$ is the expected value of y ;

- a matrix M which is the pseudoinverse matrix of $A=W \cdot Db \cdot N$, where Db is the Jacobian matrix of the first measured variables $y_i=b_i(x)$.

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5. Method in accordance with claim 4, in which

- at least one of the selected parameters is a selected state variable which can be determined via the first measured variables;
- one or more of the first sensitivity variables $\Phi_{y_j x_1}$ represents in each case the ratio of the change in accuracy $\Delta \sigma_{11}^2/x_1 = \Delta E((x_1 - E(x_1))^2)/x_1$ of the selected state variable x_1 to the change in accuracy $\Delta \sigma_{jj}^2/y_j = \Delta E((y_j - E(y_j))^2)/y_j$ of a first measured variable y_j ;
- the first sensitivity variables are determined from the following formula:

$$\Phi_{y_j x_1} = \frac{\sigma_{jj}^2}{y_j x_1} \cdot r_{1j}^2$$

20 where r_{1j} is the element in the 1th line and the j^{th} column of the matrix $N \cdot M \cdot W$.

6. Method in accordance with claim 4 or 5, in which

- at least one of the selected parameters is a selected diagnostic variable which can be determined via the first measured variables;
- a matrix Dd is determined, this being the Jacobian matrix of the diagnostic variables $d_i=d_i(x)$;
- one or more of the first sensitivity variables $\Phi_{y_j d_n}$ represents in each case the ratio of the change in accuracy $\Delta \sigma_{nn}^2/d_n = \Delta E((d_n - E(d_n))^2)/d_n$ of the selected diagnostic variable d_n to the change in accuracy $\Delta \sigma_{jj}^2/y_j = \Delta E((y_j - E(y_j))^2)/y_j$ of a first measured variable y_j ;

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- the first sensitivity variables are determined by the following formula:

$$\Phi = \frac{\sigma_{jj}^2}{y_j d_n \sigma_{nn}^2} \cdot s_{nj}^2$$

where s_{nj} is the element in the n^{th} line and the j^{th} column of $Dd \cdot N \cdot M \cdot W$.

7. Method in accordance with one of the claims 4 to 6, in which

- at least one of the selected parameters is a selected state variable which can be determined via the first measured variables;
- one or more of the second sensitivity variables represents, in each case, the variance $\sigma_{k \rightarrow x1}^2$ of the selected state variable x_1 when a second measured variable, the value of which is a state variable x_k with the variance σ_k , is being added to the measurement park;
- the second sensitivity variables are determined by the following formula:

$$\sigma_{k \rightarrow x1}^2 = m_1^T \cdot m_1 - \frac{(m_k^T \cdot m_1)^2}{\sigma_k^2 + m_k^T \cdot m_k}$$

where m_i is the i^{th} column of the matrix $M^T \cdot N$.

8. Method in accordance with one of the claims 4 to 7, in which

- at least one of the selected parameters is a selected diagnostic variable which can be determined via the first measured variables;
- a matrix Dd , which is the Jacobian matrix of the diagnostic variables $d_i = d_i(x)$, is determined;
- one or more of the second sensitivity variables

represents, in each case, the variance $\sigma_{k \rightarrow d_n}^2$ of the selected diagnostic variable d_n when a second measured variable, the value of which is a state variable x_k which has a variance σ_k , is being added to the measurement park;

- 5 - the second sensitivity variables are determined by the following formula:

$$\sigma_{k \rightarrow d_n}^2 = q_n^T \cdot q_n - \frac{(m_k^T \cdot q_n)^2}{\sigma_k^2 + m_k^T \cdot m_k}$$

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where m_i is the i^{th} column of the matrix $M^T \cdot N^T$, and q_n is the n^{th} column of the matrix and $M^T \cdot N^T \cdot D d^T$.

9. Method in accordance with one of the claims 4 to 8, in which

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- at least one of the selected parameters is a selected state variable which cannot be determined via the first measured variables;
- a matrix P , which is the orthogonal projection onto the null space of A , is determined;
- a second measured variable is determined, the value of which is a state variable x_k , and which is to be added into the measurement park so that the selected state variable can be uniquely determined;
- one of the second sensitivity variables represents the variance $\sigma_{k \rightarrow x_1}^2$ of the selected state variable when the second measured variable x_k which has been determined, and which has the variance σ_k , is being added to the measurement park;
- the second sensitivity variable is determined by the following formula:

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$$\|p\|^2 \quad \| \quad \|p\| \quad \|^2$$

$$\sigma_{k \rightarrow x1}^2 = \sigma_k^2 \cdot \frac{\|p\|^2}{\|p_k\|^2} + \frac{\|m_1 - p_k\|^2}{\|p_k\|^2},$$

with $p = Pn_1$, where n_1 is the 1th column of the matrix N^T ,
 5 and m_i is the i^{th} column of the matrix $M^T \cdot N^T$ and p_k is the
 k^{th} column of the matrix $P \cdot N^T$.

10. Method in accordance with one of the claims 4 to 9, in which

- 10 - at least one of the selected parameters is a selected
diagnostic variable which cannot be determined via the
first measured variables;
- a matrix D_d , which is the Jacobian matrix of the
diagnostic variables $d_i = d_i(x)$, is determined;
- 15 - a matrix P , which is the orthogonal projection onto the
null space of A , is determined;
- a second measured variable is determined, the value of
which is a state variable x_k , and which is to be added
into the measurement park so that the selected state
20 variable can be uniquely determined;
- one of the second sensitivity variables represents the
variance $\sigma_{k \rightarrow d_n}^2$ of the selected diagnostic variable d_n when
the second measured variable x_k which has been determined,
and which has the variance σ_k , is being added into the
25 measurement park;
- the second sensitivity variable is determined by the
following formula:

$$\sigma_{k \rightarrow d_n}^2 = \sigma_k^2 \cdot \frac{\|p\|^2}{\|p_k\|^2} + \frac{\|M^T \cdot c_n - p_k\|^2}{\|p_k\|^2},$$

with $p = Pc_n$, where c_n is the n^{th} column of the matrix

$N^T \cdot Dd^T$, m_k is the k^{th} column of the matrix $M^T \cdot N^T$ and p_k is the k^{th} column of the matrix $P \cdot N^T$.

5 11. Method in accordance with claim 9 or 10, by which the matrix $P \cdot N^T$ is searched for the column such that p is a linear function of this column, where the index k of this column specifies that the second measurement value x_k is to be added into the measurement park so that the selected parameter can be uniquely determined.

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12. Method in accordance with one of the claims 7 to 11, in which the standard deviation σ_k of the second measured variable is 1% of the value of the second measured variable.

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13. Device for analyzing a technical system which is equipped in such a way that a method in accordance with one of the preceding claims can be performed.

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14. Computer program produce which has a storage medium on which is stored a computer program which can be executed on a computer and with which the method in accordance with one of the claims 1 to 12 can be performed.